

CLAIMS

1. A method for monitoring operational status of a cyclically operated valve (5, 19), which valve is operated to allow a fluid or gaseous medium to flow from a first conduit (1, 18) to a second conduit (3, 5 20) due to a pressure difference between said conduits, whereby the valve (5, 19) operated using at least one predetermined duty cycles, comprising:
 - measuring pressure oscillations caused by the valve (5, 19) and generating an output signal;
 - 10 performing a frequency analysis on the signal to determine an amplitude for the signal at an oscillation frequency;
 - comparing the amplitude of the oscillations to an expected amplitude for the oscillation frequency; and
 - generating an error signal if the difference between the calculated and the expected amplitudes exceeds a predetermined limit.
- 15 2. The method according to claim 1 wherein measuring of the pressure oscillations is performed when the duty cycle is within the range 30-50%.
3. The method according to claim 2 wherein measuring of the pressure oscillations is performed using continuous sampling.
- 20 4. The method according to claim 2 wherein the duty cycle is at or near 50%.
5. The method according to claim 4 wherein, when the duty cycle is substantially constant, measuring of the pressure oscillations is performed using constant sampling.
- 25 6. The method according to claim 4 wherein, when the duty cycle is variable, measuring of the pressure oscillations is performed using intermittent sampling, whenever the duty cycle is at or near 50%.

7. The method according to claim 4 wherein when the duty cycle is variable, measuring of the pressure oscillations is performed using a regular sampling, by setting the duty cycle to 50% at predetermined intervals.

5 8. The method according to claim 1 wherein the valve (5, 19) is determined to be malfunctioning if the calculated amplitude is significantly lower than the expected amplitude.

9. The method according to claim 8 wherein the valve (5, 19) is determined to be malfunctioning if the calculated amplitude is at 10 or near zero.

10. The method according to claim 1 wherein the frequency analysis is performed using a discrete Fourier transformation.

11. The method according to claim 10 wherein the discrete Fourier transformation used to determine the amplitude of the 15 signal is

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-j2\pi kn/N}$$

where $k = [0, N-1]$ and;

$X(k)$ is the frequency spectrum as a function of k , which defines the equally spaced frequencies $\omega_k = 2\pi k/N$, and

20 $x(n)$ is the signal vector to transform, as a function of the time index n ,

N is the number of samples to transform.

12. An arrangement for monitoring operational status of a cyclically operated valve (5, 19), which valve is operated to allow a fluid or gaseous medium to flow from a first conduit (1, 18) to a second conduit (3, 5 20) due to a pressure difference between said conduits, whereby the valve (5, 19) is arranged to be operated at a predetermined frequency and at various duty cycles, comprising:

10 a pressure sensor (2, 23) arranged to measure pressure oscillations caused by the valve (5, 19) in at least one of the said conduits (1, 18; 3, 23) and to generate an output signal;

15 a control unit (4, 24) coupled to said pressure sensor performs a frequency analysis on the output signal to calculate an amplitude for the signal at the oscillation frequency said control unit (4, 24) further compares said calculated amplitude to an expected amplitude for the oscillation frequency of a particular duty cycle, said control unit further generates an error signal when a difference between said calculated and said expected amplitudes exceed a predetermined limit.

20 13. The arrangement according to claim 12 wherein the valve (5, 19) is operated at a duty cycle within the range 30-70%.

14. The arrangement according to claim 13 wherein the valve (5, 19) is operated at a duty cycle at or near 50%.

15. The arrangement according to claim 12 wherein said pressure sensor (2, 23) is located downstream of the valve (5, 19).

25 16. The arrangement according to claim 12 wherein said pressure sensor (2, 23) is located upstream of the valve (5, 19).

17. The arrangement according to claim 12 wherein said frequency analysis performed is a discrete Fourier transformation.

18. The arrangement according to claim 17 wherein said discrete Fourier transformation performed to determine the amplitude of said signal is

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-j2\pi kn/N}$$

5 where $k = [0, N-1]$ and;
 $X(k)$ is a frequency spectrum as a function of k , at equally spaced frequencies $\omega_k = 2\pi k/N$, and
 $x(n)$ is a signal vector to transform, as a function of time index n ,
10 N is a number of samples to transform.

19. The arrangement according to claim 12 wherein said control unit (4, 24) further generates an error signal when said calculated amplitude is significantly lower than said expected amplitude.

20. The arrangement according to claim 12 wherein said control unit (4, 24) further generates an error signal when the calculated amplitude is at or near zero.
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21. The arrangement according to claim 12 wherein the first conduit (1, 18) is connected to a canister (13) arranged to absorb vapor from a container.

20 22. The arrangement according to claim 21, wherein said vapor is evaporated fuel from a fuel tank (10).

23. The arrangement according to claim 12 wherein the second conduit (3, 20) is connected to an air intake manifold (21) for an internal combustion engine (17).

25 24. The arrangement according to claim 23 wherein said pressure sensor (23) in said intake manifold (21) is arranged to measure the pressure oscillations upstream of said pressure sensor.

25. The arrangement according to claim 23 wherein said pressure sensor (23) in said intake manifold (21) is arranged to measure pressure oscillations downstream of said pressure sensor.